Aerosol and Air Quality Research, 18: I–IV, 2018

ISSN: 1680-8584 print / 2071-1409 online
doi: 10.4209/aaqr.2018.09.MAPS

Preface to a Special Issue "Megacity Air Pollution Studies (MAPS)"

Guest Editors
Yong Pyo Kim, Professor, Ewha Woman's University, Korea (yong@ewha.ac.kr)
Gangwoong Lee, Professor, Hankuk Univrsity of Foreign Studies, Korea (gwlee@hufs.ac.kr)
Louisa Emmons, Senior Scientist, National Center for Atmospheric Research, USA (emmons@ucar.edu)
Rokjin Park, Professor, Seoul National University, Korea (rjpark@snu.ac.kr)

Overseeing Editor-in-Chief
Prof. Neng-Huei Lin, National Central University, Taiwan

Large urban areas, commonly referred to as *megacities*, generally consume a huge amount of energy due to the high population density along with concentrated economic activities, and the resulting environmental burden—including air pollution—is an ongoing scientific and public issue. As several common factors and drivers cause air pollution problems in urban areas, it is widely thought that the air quality trends in different cities exhibit similarities in certain aspects correlated with urban development activity and air pollution mitigation practices. However, unique characteristics in the emission, chemistry, and dispersion of air pollutants that are specific to each urban area also exist, which often reflect differing approaches to air pollution control policy. Based on this reasoning, several comprehensive studies in big megacities, mostly in North America and Europe, have been implemented extensively over the last two decades. However, the air quality is often much poorer in the megacities of developing countries, and extensive research is still needed to tackle the urgent goals of understanding the increasing complexity of air quality and identifying appropriate mitigation measures. This MAPS (Megacity Air Pollution Studies) special issue highlights recent scientific findings from megacity air-quality research in many parts of the world. It focuses primarily on the mechanisms and drivers that result in high ozone and aerosol events in megacities but also addresses the latest advances in precursor emissions inventories, chemical transformation assessments, and forecasting models with sets of field observations, including remote sensing applications.

Having made significant progress with reducing air pollution by the late 1990s in terms of primary pollutants (NO_x, SO_2, CO, and PM_{10}), South Korea launched a series of long-term 10-year plans (Phase I for 2005–2014 and Phase II for 2015–2024) to further improve its air quality, mostly in the Seoul Metropolitan Area (SMA). To date, the air quality goals of Phase I have mostly been achieved for PM_{10} and NO_x in SMA. However, the existing policy has not been effective in reducing secondary air pollutants, such as $PM_{2.5}$ and ozone, despite rigorous and comprehensive efforts to concurrently reduce their precursor emissions (Kim and Lee, 2018, this issue). Thus, it is essential to investigate the unresolved issues responsible for the lack of improvement with these species, as our understanding of their behavior remains very limited and critical questions continue to be raised for current emission-reduction plans and policy.

To identify the characteristics of air pollution in Seoul, the Megacity Air Pollution Studies-Seoul (MAPS-Seoul) campaign was conducted. Beginning in 2014, it was the first integrated air-quality research program in South Korea and a collaborative activity for the 2016 KORUS-AQ (International Cooperative Air Quality Field Study in Korea). The main scientific goals of MAPS-Seoul were to assess and reduce the uncertainties regarding precursor emissions, chemical transformations, and the long-range transport of air pollutants. The campaign focused on detailed observation-based analysis using 17 ground sites, a research aircraft, ensembles of four air-quality models, and a satellite. 32 investigators from 21 research institutes and universities participated in these field studies between May 18 and June 12, 2015. In addition to ground sites densely located within SMA, three key sites were designated on Baengnyeong Island (an upwind site), on the campus of KIST (Korea Institute of Science and Technology) (an urban site), and at the Taehwa Mountain Forest Research site (a downwind site) to characterize the evolution of $PM_{2.5}$, ozone, and their precursors along the prevailing westerly.

In order to publicize the results of the MAPS-Seoul study and obtain more information from experts in the same research area, a special *AAQR* issue for MAPS has been prepared. It is our great pleasure to publish this issue featuring 30 research articles, of which 12 are related to MAPS-Seoul and 18 to air quality problems in other megacities. Through this research, we expect to form a far more substantial image of air pollution in large urban areas.

The 12 papers related to air quality in SMA focus primarily on the physical and chemical drivers that determine aerosol exposure and photochemistry in the region. Detailed historical backgrounds and challenging issues, mainly regarding the $PM_{2.5}$ and ozone in Seoul, are reviewed by Kim and Lee, who state that it is essential to develop reliable emissions inventories and to understand major chemical transformations for $PM_{2.5}$ and ozone as a prerequisite for creating effective control policies. Meteorological conditions during the MAPS-Seoul 2015 intensive field campaign were heavily influenced by a strong El

Niño event and thus much warmer and drier than the climatological condition (Park, 2018, this issue). A series of migratory cyclones and anticyclones affected large-scale synoptic patterns in East Asia and occasionally induced the long-range transport of air pollutants from China to the Korean Peninsula with strong geostrophic winds and high humidity (Kim *et al.*, 2018a, this issue). Despite the influence of transboundary transport, the observed $PM_{2.5}$ concentrations in the surface air in Seoul and South Korea during the campaign were lower than values in the past (Lee *et al.*, 2018a, this issue). Dominant contributions from domestic emissions to air pollutant concentrations during the campaign were confirmed through the analysis of remote sensing observations of the aerosol optical depth (Lee *et al.*, 2018b, this issue) and NO_2 column density on the Peninsula (Chong *et al.*, 2018, this issue).

Analyzing year-long observations of the $PM_{2.5}$ composition in Seoul, Park *et al.* (2018, this issue) identified ammonium sulfate as the most dominant compound (30.3%) in the fine particles, followed by ammonium nitrate (25.2%), organic matter (21.3%), crustal mass (16.9%), element carbon (6.1%), and trace metals (0.2%). Park *et al.* (2018, this issue) also imply that the IMPROVE algorithm tends to underestimate aerosol light extinction—with discrepancies as high as 30%—in Seoul, where large and fresh sources of organic matter and black carbon exist. Two independent studies reveal the potential for significant public exposure in underground tunnels to nanoparticles, which are most likely generated by the wheel-rail contact of subway trains in Seoul (Lee *et al.*, 2018c, this issue; Woo *et al.*, 2018, this issue). The OH reactivity study by Kim *et al.* (2018c, this issue) shows that the total OH reactivity levels and the relative concentrations of VOCs (volatile organic compounds) and NO_x play critical roles in ozone production rates, furthermore noting that isoprene (a biogenic VOC) consistently contributed the most to OH reactivity among the observed VOCs in the afternoon during the entire MAPS-Seoul field campaign. Observing its correlation with levels of local biogenic VOCs and transported NO_x, Gil *et al.* (2018, this issue) demonstrates that PAN at the Taehwa forest site is a more sensitive indicator than ozone for illustrating the locally enhanced *in-situ* photochemistry in transported urban plumes. Also, Kim *et al.* (2018b, this issue) identified major meteorological and chemical factors controlling ozone formation in Seoul during MAPS-Seoul 2015.

The remaining 18 articles cover a broad range of topics and locations. The spatial distribution comprises North America (Los Angeles in Lovett *et al.* (2018, this issue) and Guadalajara in Cerón-Bretón *et al.* (2018, this issue)), South America (São Paulo in Alvim *et al.* (2018, this issue) and São Paulo and Rio de Janeiro in Vormittag *et al.* (2018, this issue)), Asia (Karachi in Shahid *et al.* (2018, this issue), 16 Chinese cities in Gong *et al.* (2018, this issue), Manila in Alas *et al.* (2018, this issue) and Kecorius *et al.* (2018, this issue), 5 Chinese cities in Zhao *et al.* (2018, this issue), 109 Indian cities in Pal *et al.* (2018, this issue), Jakarta in Kusumaningtyas *et al.* (2018, this issue), New Delhi in Kumar *et al.* (2018, this issue) and Mukherjee *et al.* (2018, this issue), the Pearl River Delta Region and Hong Kong in Lin *et al.* (2018, this issue), Hanoi in Ly *et al.* (2018, this issue), Tianjin in Han *et al.* (2018, this issue), and Beijing in Yu *et al.* (2018, this issue)), and Oceania (Sydney in Aryal *et al.* (2018, this issue)).

Several articles address the spatial and temporal trends of aerosols, gaseous species such as ozone, and rain (the spatial distribution of ozone in 16 Chinese cities in Gong *et al.* (2018, this issue), the spatial characterization of black carbon in Manila in Alas *et al.* (2018, this issue), spatio-temporal variations of $PM_{2.5}$ in 5 Chinese cities in Zhao *et al.* (2018, this issue), the temporal trend of $PM_{2.5}$ in Indian cities in Pal *et al.* (2018, this issue), spatial and temporal trends of rain and aerosols in Jakarta in Kusumaningtyas *et al.* (2018, this issue), and the temporal trend of $PM_{2.5}$ in the Pearl River Delta Region and Hong Kong in Lin *et al.* (2018, this issue)), whereas others investigate more specific topics, viz., the health risks or effects of commuting (Lovett *et al.*, 2018, this issue), the implementation of biodiesel (Vormittag *et al.*, 2018, this issue), the short-term health effects of air pollution (Cerón-Bretón *et al.*, 2018, this issue), personal exposure to air pollutants in daily time-activity patterns of urban population (Kecorius *et al.*, this issue), the impact of a wildfire (Aryal *et al.*, 2018, this issue), the influence of open waste burning (Kumar *et al.*, 2018, this issue), the characterization of tracers of biomass burning (Yu *et al.*, 2018, this issue), the estimation of ozone-forming potential (Alvim *et al.*, 2018, this issue), and the microphysics of fog and haze at the top of the urban canopy (Han *et al.*, 2018, this issue).

The extensive variety in the spatial and temporal distribution of these research topics indicates that air pollution in megacities must be evaluated by various metrics, as it can affect a multitude of environmental aspects. This range also supports the hypothesis that each urban area is influenced by air quality factors that are specific to its location. Note that 12 of the 18 articles are on Asian megacities, where rapid economic growth and high population have resulted in severe air pollution, mostly originating in fossil fuel combustion. Therefore, scientifically supported data on the characteristics of air quality in these urban areas and their impacts on human health are crucial.

We are indebted to all of the authors who have submitted original work to this special issue. We are also thankful to the reviewers for their efforts and the administrative staff of *AAQR* for their support in publishing this issue.

REFERENCES

Alas, H.D., Müller, T., Birmili, W., Kecorius, S., Cambaliza, M.O., Simpas, J.B.B., Cayetano, M., Weinhold, K., Vallar, E., Galvez, M.C. and Wiedensohler, A. (2018). Spatial characterization of black carbon mass concentration in the atmosphere of a Southeast Asian megacity: An air quality case study for Metro Manila, Philippines. *Aerosol Air Qual. Res.* 18: 2301–2317.

Alvim, D.S., Gatti, L.V., Corrêa, S.M., Chiquetto, J.B., Santos, G.M., de Souza Rossatti, C., Pretto, A., Rozante, J.R., Figueroa, S.N., Pendharkar, J. and Nobre, P. (2018). Determining VOCs reactivity for ozone forming potential in the megacity of São Paulo. *Aerosol Air Qual. Res.* 18: 2460–2474.

Aryal, R., Kafley, D., Beecham, S. and Morawska, L. (2018). Air quality in the Sydney metropolitan region during the 2013 Blue Mountains wildfire. *Aerosol Air Qual. Res.* 18: 2420–2432.

Cerón-Bretón, R.M., Cerón-Bretón, J.G., Lara-Severino, R.C., Espinosa-Fuentes, M.L., Ramírez-Lara, E., Rangel-Marrón, M., Rodríguez-Guzmán, A. and Uc-Chi, M.P. (2018). Short-term effects of air pollution on health in the metropolitan area of Guadalajara using a time-series approach. *Aerosol Air Qual. Res.* 18: 2383–2411.

Chong, H., Lee, H., Koo, J.H., Kim, J., Jeong, U., Kim, W., Kim, S.W., Herman, J.R., Abuhassan, N.K., Ahn, J., Park, J.H., Kim, S.K., Moon, K.J., Choi, W.J. and Park, S.S. (2018). Regional characteristics of NO_2 column densities from Pandora observations during the MAPS-Seoul campaign. *Aerosol Air Qual. Res.* 18: 2207–2219.

Gil, J., Lee, M., Han, J., Kim, S., Guenther, A., Kim, H., Kim, S. and Park, H. (2018). Peroxyacetyl nitrate and ozone enhancement at Taehwa research forest under the influence of Seoul Metropolitan Area. *Aerosol Air Qual. Res.* 18: 2262–2273.

Gong, X., Hong, S. and Jaffe, D.A. (2018). Ozone in China: Spatial distribution and leading meteorological factors controlling O_3 in 16 Chinese cities. *Aerosol Air Qual. Res.* 18: 2287–2300.

Han, S.Q., Hao, T.Y., Zhang, M., Yao, Q., Liu, J.L., Cai, Z.Y. and Li, X.J. (2018). Observation analysis on microphysics characteristics of long-lasting severe fog and haze episode at urban canopy top. *Aerosol Air Qual. Res.* 18: 2475-2486.

Kecorius, S., Tamayo, E.G., Galvez, M.C., Madueño, L., Betito, G., Gonzaga-Cayetano, M., Vallar, E. and Wiedensohler, A. (2018). Activity pattern of school/university tenants and their family members in Metro Manila – Philippines. *Aerosol Air Qual. Res.* 18: 2412–2419.

Kim, C.H., Lee, H.J., Kang, J.E., Jo, H.Y., Park, S.Y., Jo, Y.J., Lee, J.J., Yang, G.H., Park, T. and Lee, T.H. (2018a). Meteorological overview and signatures of long-range transport processes during the MAPS-Seoul 2015 campaign. *Aerosol Air Qual. Res.* 18: 2173–2184.

Kim, H., Choi, W.C., Rhee, H.J., Suh, I., Lee, M., Blake, D.R., Kim, S., Jung, J., Lee, G., Kim, D.S., Park, S.M., Ahn, J. and Lee, S.D. (2018b). Meteorological and chemical factors controlling ozone formation in Seoul during MAPS-Seoul 2015. *Aerosol Air Qual. Res.* 18: 2274–2286.

Kim, S., Jeong, D., Sanchez, D., Wang, M., Seco, R., Blake, D., Meinardi, S., Barletta, B., Hughes, S., Jung, J., Kim, D., Lee, G., Lee, M., Ahn, J., Lee, S.D., Cho, G., Sung, M.Y., Lee, Y.H. and Park, R. (2018c). The controlling factors of photochemical ozone production in Seoul, South Korea. *Aerosol Air Qual. Res.* 18: 2253–2261.

Kim, Y.P. and Lee, G. (2018). Trend of air quality in Seoul: Policy and science. *Aerosol Air Qual. Res.* 18: 2141–2156.

Kumar, S., Aggarwal, S.G., Sarangi, B., Malherbe, J., Barre, J.P.G., Berail, S., Séby, F. and Donard, O.F.X. (2018). Understanding the influence of open-waste burning on urban aerosols using metal tracers and lead isotopic composition. *Aerosol Air Qual. Res.* 18: 2433–2446.

Kusumaningtyas, D.A., Aldrian, E., Wati, T., Atmoko, D. and Sunaryo, S. (2018). The recent state of ambient air quality in Jakarta. *Aerosol Air Qual. Res.* 18: 2343–2354.

Lee, G., Oh, H.R., Ho, C.H., Park, D.S.R., Kim, J., Chang, L.S., Choi, J. and Sung, M. (2018a). Slow decreasing tendency of fine particles compared to coarse particles associated with recent hot summers in Seoul, Korea. *Aerosol Air Qual. Res.* 18: 2185–2194.

Lee, S., Hong, J., Cho, Y., Choi, M., Kim, J., Park, S.S., Ahn, J.Y., Kim, S.K., Moon, K.J., Eck, T.F., Holben, B.N. and Koo, J.H. (2018b). Characteristics of classified aerosol types in South Korea during the MAPS-Seoul campaign. *Aerosol Air Qual. Res.* 18: 2195–2206.

Lee, Y., Choi, K., Jung, W., Versoza, M.E., Barabad, M.L.M., Kim, T. and Park, D. (2018c). Generation characteristics of nanoparticles emitted from subways in operation. *Aerosol Air Qual. Res.* 18: 2230–2239.

Lin, C., Li, Y., Lau, A.K.H., Li, C. and Fung, J.C.H. (2018). 15-year $PM_{2.5}$ trends in the Pearl River Delta region and Hong Kong from satellite observation. *Aerosol Air Qual. Res.* 18: 2355–2362.

Lovett, C., Shirmohammadi, F., Sowlat, M.H. and Sioutas, C. (2018). Commuting in Los Angeles: Cancer and non-cancer health risks of roadway, light-rail and subway transit routes. *Aerosol Air Qual. Res.* 18: 2363–2374.

Ly, B.T., Matsumi, Y., Nakayama, T., Sakamoto, Y., Kajii, Y. and Nghiem, D.T. (2018). Characterizing $PM_{2.5}$ in Hanoi with new high temporal resolution sensor. *Aerosol Air Qual. Res.* 18: 2487–2497.

Mukherjee, T., Asutosh, A., Pandey, S.K., Yang, L., Gogoi, P.P., Panwar, A. and Vinoj, V. (2018). Increasing potential for air pollution over megacity New Delhi: A study based on 2016 Diwali episode. *Aerosol Air Qual. Res.* 18: 2510–2518.

Pal, R., Chowdhury, S., Dey, S. and Sharma, A.R. (2018). 18-year ambient $PM_{2.5}$ exposure and night light trends in Indian cities: Vulnerability assessment. *Aerosol Air Qual. Res.* 18: 2332–2342.

Park, M.S. (2018). Overview of meteorological surface variables and boundary-layer structures in the Seoul Metropolitan Area during the MAPS-Seoul campaign. *Aerosol Air Qual. Res.* 18: 2157–2172.

Park, S.M., Song, I.H., Park, J.S., Oh, J., Moon, K.J., Shin, H.J., Ahn, J.Y., Lee, M.D., Kim, J. and Lee, G. (2018). Variation of $PM_{2.5}$ chemical compositions and their contributions to light extinction in Seoul. *Aerosol Air Qual. Res.* 18: 2220–2229.

Shahid, I., Alvi, M.U., Shahid, M.Z., Alam, K. and Chishtie, F. (2018). Source apportionment of PM_{10} at an urban site of a south Asian mega city. *Aerosol Air Qual. Res.* 18: 2498–2509.

Vormittag, E.M.P.A., Rodrigues, C.G., de André, P.A. and Saldiva, P.H.N. (2018). Assessment and valuation of public health impacts from gradual biodiesel implementation in the transport energy matrix in Brazil. *Aerosol Air Qual. Res.* 18: 2375–2382.

Woo, S.H., Kim, J.B., Bae, G.N., Hwang, M.S., Tahk, G.H., Yoon, H.H. and Yook, S.J. (2018). Investigation of diurnal pattern of generation and resuspension of particles induced by moving subway trains in an underground tunnel. *Aerosol Air Qual. Res.* 18: 2240–2252.

Yu, J., Yan, C., Liu, Y., Li, X., Zhou, T. and Zheng, M. (2018). Potassium: A tracer for biomass burning in Beijing? *Aerosol Air Qual. Res*. 18: 2447–2459.

Zhao, D., Chen, H., Sun, X. and Shi, Z. (2018). Spatio-temporal variation of $PM_{2.5}$ pollution and its relationship with meteorology among five megacities in China. *Aerosol Air Qual. Res.* 18: 2318–2331.